SCOTT

The Development of an Irrigation Project

Civil Engineering

B. S.

1907

THE DEVELOPMENT
OF
AN IRRIGATION PROJECT

BY

JAMES ROBINSON SCOTT, JR.

THESIS

FOR

DEGREE OF BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1907

C O L L E G E O F E N G I N E E R I N G

April 30, 1907.

This is to certify that the following thesis prepared under the immediate direction of Professor J. P. Brooks, Assistant Professor of Civil Engineering, by

JAMES ROBINSON SCOTT, JR.

entitled DEVELOPMENT OF AN IRRIGATION PROJECT
IN LARIMER COUNTY, COLORADO

is accepted by me as fulfilling this part of the requirements for the Degree of Bachelor of Science in Civil Engineering.

Ira O. Baker

Head of Department of Civil Engineering.

The Developement Of An Irrigation Project.

Introduction.

- Location.
- Description.
- Source of Supply.

Laws relating to Water Rights.

- State of Colorado.

Description of Survey.

- Methods Employed.

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- Maps.
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- Design of Gates, Weirs.

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Introduction.

Irrigation,as practiced both in foreign countries and in the United States,has been found to be one of the most efficient methods of increasing the agricultural resources of a country. It is estimated that at the present time approximately 5,000,000 acres of land are being irrigated in this country. Its importance can more clearly be seen when it is noted that the United States Reclamation Service is planning to spend fifty millions of dollars in the developing of the arid regions of the western states. Private enterprises have already spent many times that sum in similar work. Lands which had before been considered fit for nothing,have been turned into valuable agricultural tracts.

The district with which this investigation has to deal, lies in Larimer County,Colorado,and is known as Estes Park. The land to be developed is in the valley lying north of Long's Peak. It consists of about eight thousand acres of flat land, and is so located that farm products ,such as fruit and grain,could readily be disposed of at market in either Lyons or Loveland,Colorado. The accompanying map shows the location of the reservoir site with reference to the towns mentioned.

A careful study of the climatic conditions reveals the necessity of providing some means of water storage,so that the water may be collected during the wet months of May and June and distributed during the dry months of August and September. The stream from which the water is to be stored

is the Big Thompson Creek,which has its source north and west of Long's Peak and flows the entire length of the valley which which forms Estes Park. The gradient of the stream is very great and little difficulty is encountered in raising the water to the necessary height for emptying it into flumes.

The problem then resolves itself into one of selecting a suitable reservoir site and constructing a dam for the collection of the flood water which occurs during the early spring months.

MAP
SHOWING LOCATION OF
FOREST CANON RESERVOIR
LARIMER CO. COLORADO
Thesis of
J. R. Scott

Laws relating to Water Rights.

Water rights have always been justly regarded as one of the most important subjects dealt with in the legislation and jurisprudence of the state of Colorado. Notwithstanding the importance of this side of the developement of an irrigation project, this investigation will give merely a digest of the present laws and will deal entirely with the legal proceedings which are necessary for its completion.

Right of Appropriation.

The water of every natural stream within the state of Colorado not heretofore appropriated, is dedicated to the use of the public and the same is declared to be the property of the people of the state, subject to appropriations as provided for in the following enactments. The right to unappropriated waters of any natural stream, for beneficial purposes, shall never be denied. Priority of appropriation shall give the better right as between those using water for the same purpose, but when the waters of a stream are not sufficient for the use of all desiring them, those using the water for domestic purposes shall have the preference over those using them for other purposes.

Validity of Appropriation.

One may make valid appropriation of surplus water in the above manner, even though an actual diversion does not take place until a later time. The act of utilizing, as a reser-

-voir,a natural depression which includes the bed of the stream itself,or which was formed as a source thereof,is not in itself,lawful. A person attempting to appropriate water in the above manner does so at his own risk. He must see to it that no legal rights of prior appropriation or of other persons are interfered with in any way by his acts. He cannot lessen the flow of the water,seriously impair its quality, or impede the natural flow of the stream to the detriment of others who have acquired rights thereon superior to his. In case of such injury to property, he is held liable for full damages. In general,according to the laws of the state, rights to the beneficial use of water from natural streams have been by rights obtained by actual diversion rather than by any form of grant.

Court Decisions.

It is a settled doctrine of the courts of the state that any form of appropriation,to be valid,must be accompanied by the sucessful application of water to the use designed or a visible demonstration to do the same.

Construction of Dams for Reservoirs.

In the absence of any written law regarding the construction or maintenance of dams for reservoirs,a person may have the legal right to construct his dam on any natural stream and in this way reserve water for useful purposes,so long as he does not encroach upon the rights and interests of others. The owner of any reservoir may conduct the water from it,into and

along any natural stream,but not so as to raise the water above ordinary high water and may take it out again,due allowance having been made for losses due to seepage. One who constructs a dam or ditch for the purpose of appropriating water,is bound to exercise care and prudence in the construction and maintenance thereof. The owner of the dam or ditch is liable for full damages to neighbors either in a permanent or temporary manner. All designs for waste ways shall be made by competant engineers and in case of large projects meet the approval of the State Engineer.

All other laws in regard to the construction of waste-weirs,discharge gates,etc,will be noted under the head of "Designs".

Maximum Flood flow.

As the accurate determination of the maximum flood flow of the Big thompson was a vital point in the investigation no pains was spared in getting reliable data on that subject. The following letter was finally accepted as the most reliable data on the flood flow which shoul be cared for in the construction of the waste-weir.

The Agricultural Experiment Station.
State Agricultural College.
Fort Collins Colorado.

L.G.Carpenter, Director.
Irrigation Engineer.

Nov, 26th, 1906.

James R.Scott, Jr.

507 S.State St.

Champaign, Ill.

Dear Sir:-

I have your favor of Nov.1rth in regard to the flow of the Big Thompson, near Moraine Park. Measurements have been made of the Big Thompson for quite a number of years though not near Estes Park. The maximum flow may be considered as about 2000 cubic feet per second and presumably the flow at the point you mention, probably is 1000 feet.

Respectfully yours,

'L.G.Carpenter.'

Description of the Survey.

In carrying on this investigation, the following surveys were necessary; (1). Survey of the Reservoir Site. (2). Survey of the Dam Site. (3). Measurements of the flow of the Big Thompson Creek.

In making the survey of the reservoir site the transit-stadia method was used. A forty foot high-water contour was run around the depression which formed the reservoir. Owing to the extreme roughness of the country, transit stations were established at frequent intervals, from which the topography of the surrounding territory was taken. This traverse line was tied to a large cairn of rocks piled near the dam site. The magnetic declination was assumed to be N 14 degrees, 30 minutes E, this being the usual declination assumed in this district.

The survey of the dam site presented some slight difficulties. Owing to the roughness of the ground and to the steepness of the canon walls, the usual methods could not be used conveniently. The dam site was divided into a system of rectangles by means of rectangular coordinates and the elevation of the various corners found by suspending a graduated chord from an over-head trolley which was lined up so as to follow a row of the points to be determined.

A gauging of the stream was made at a point near the dam site. This was accomplished by measuring the cross-section of the stream at a particular point and then finding the surface velocity by using floats. The rate of flow thus determined, serves merely as a guide for comparison with the mean annual flow.

Choice of Dam.

The dam site is located at a point where the two walls of the canon come very close together. Both walls are very steep and form an opening which requires a dam forty (40) feet high to have a lenght of crest of only eighty (80) feet. The foundation is of solid granite gneiss and is entirely impervious. Timber and loose rock are plentiful on or near the dam site. The absence of earth in any form is a peculiar feature of the entire district.

In making a choice of the type of dam to be used,recent engineering literature was consulted to a large extent. Of the types of dams used under similar circumstances,the following were the most numerous,and seemingly,the most efficient. (1).Loose-rock.(2).Timber-crib.(3).Earth.(4).Masonry.

The great distance of the dam site from the rail road makes the masonry dam out of the question on account of the large quantities of cement necessary for its construction. The absence of earth also renders the earth dam impracticable. The fact that timber and loose rock are to be had in large quantities close at hand,makes the selection of either the the loose rock or timber-crib dams feasable. For the purposes of this investigation the loose rock type of dam will be designed.

The most effective form of loose rock dam is one,over the crest of which,no water is allowed to flow. In this form the crest of the rock fill should not be less than eight(8)

feet,the down stream slope one and one half to one and the up-stream slope one half to one. The above proportions are being used repeatedly in the construction of the majority of the loose rock dams in the West at the present time. The discussion of loose rock dams in Schuyler's"Reservoirs for Irrigation" may be considered to be the most authoritative.

Assuming the width of crest to be eight (8) feet,the slope of the up-stream to be one and one half to one,the slope of the down stream side tobe one half to one,and the height to be forty(40) feet,an investigation of the forces acting on the structure shows the dam to be very stable and to have high factors of safety against crushing,sliding and over turning.

It is obvious that a dam built of loose rock is not entirely water-tight. There two methods in use by which a dam of this type can be made water-tight; first,to fill the upstream slope with a coating of six(6) or eight(8) feet of well compacted earth. For this dam this would be out of the question owing to the scarcity of any form of earth. The second method is to place double thickness of timber sheathing on the up-stream slope. This is accomplished be laying vertical timbers in the rubble masonry wall and spiking the horizontal timbers to them. Planking twelve (12) inches wide and two(2) inches thick is usually used. The vertical members should be about eight(8) inches square. They are secured more firmly to the masonry by means of one(1) inch tie rods,four(4) feet long.

DESIGN OF LOOSE ROCK DAM

LARIMER COUNTY, COLORADO

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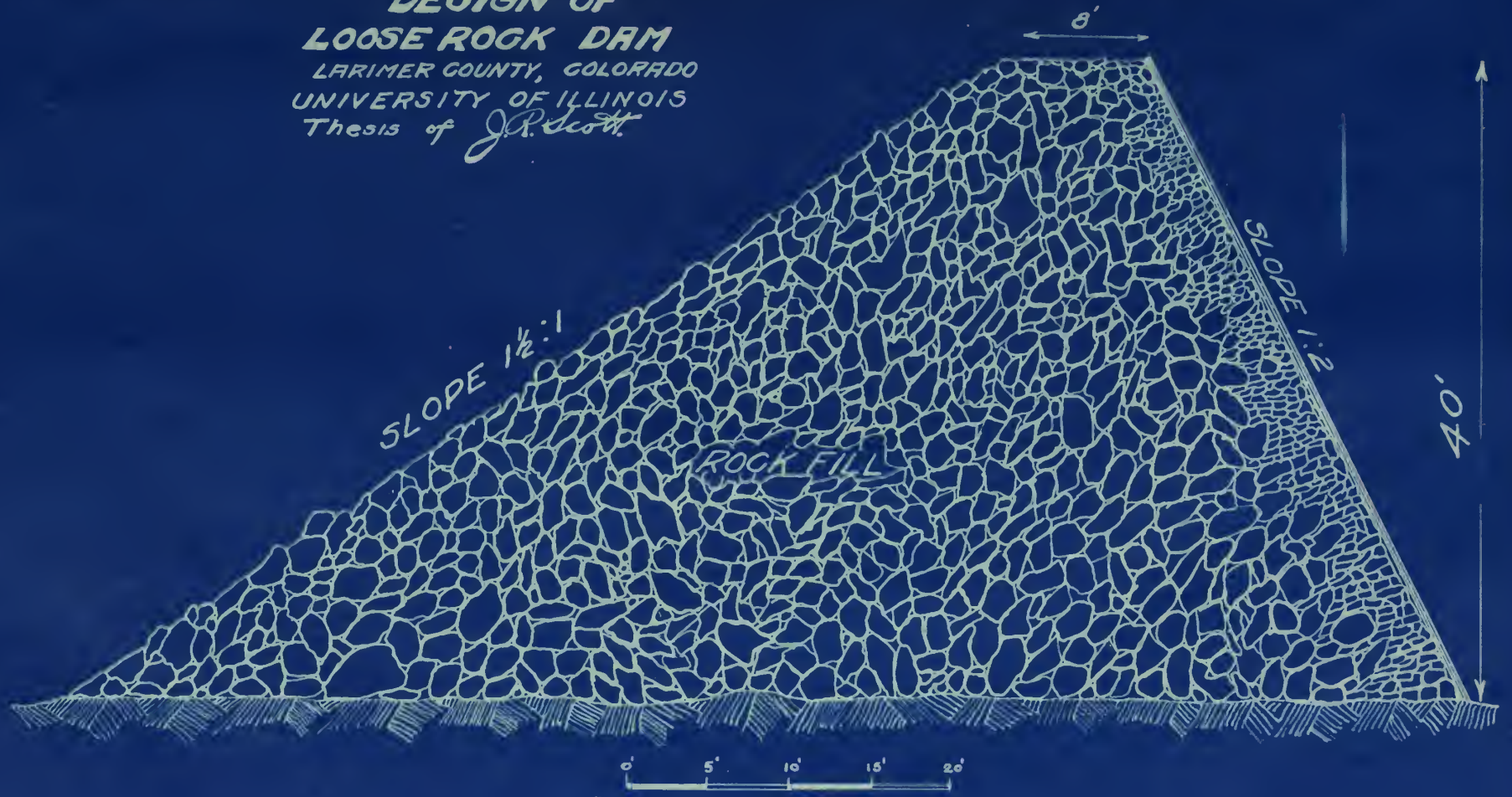

Design of the Waste Weir.

In designing the waste weir, two features present themselves as the most essential ones. First to make the weir of sufficient capacity to care for the maximum flood flow, and second, to place the weir at such a point that water falling over to the stream bed below will not injure the dam and render the structure unstable. Most failures of loose rock dams have been caused by the flood waters wearing away the toe of the down stream slope. Having in mind these things, the importance of gaining reliable imformation as to the maximum flood flow is realized. The most reliable source of imformation on this subject was found to be the reports of the Hydrographic Department of the United States Geological Survey. These reports contain data on the maximum flood flow together with regular gaugings of a great number of streams. While the Big Thompson Creek has not been gauged in the above manner, comparisons were made with the nearby streams which were under similar conditions. After a careful study of the available data the flood flow was estimated to be One thousand (1000) cubic feet per second.

Knowing the required capacity of the weir the dimensions were computed from the following formula, $1000 = 3.33LH^{3/2}$ in which L equals the length of crest in feet and H equals the depth of the water in feet. The weir as designed has a lenght of crest of twenty (20) feet and a depth of flow of five (5) feet. The accompanying curve shows the relation of variables in the equation given above. The things to be

considered in the design were that the depth should not be too great owing to the necessity of an increase of the height of the dam, and that it should not be so shallow as to allow of loss of water on account of the necessary great length of crest.

The accompanying plate shows to location of the waste weir with referenc to the dam.

$Q = 1000 = 3.33 L H^{\frac{3}{2}}$

Q = Cu. Ft. Per Sec.

L = Length of Crest (Ft.)

H = Head on Weir (Ft.)

CURVE SHOWING RELATION OF LENGTH OF CREST TO HEAD FOR DISCHARGE OF 1000 C.F.M. 1 Sec.

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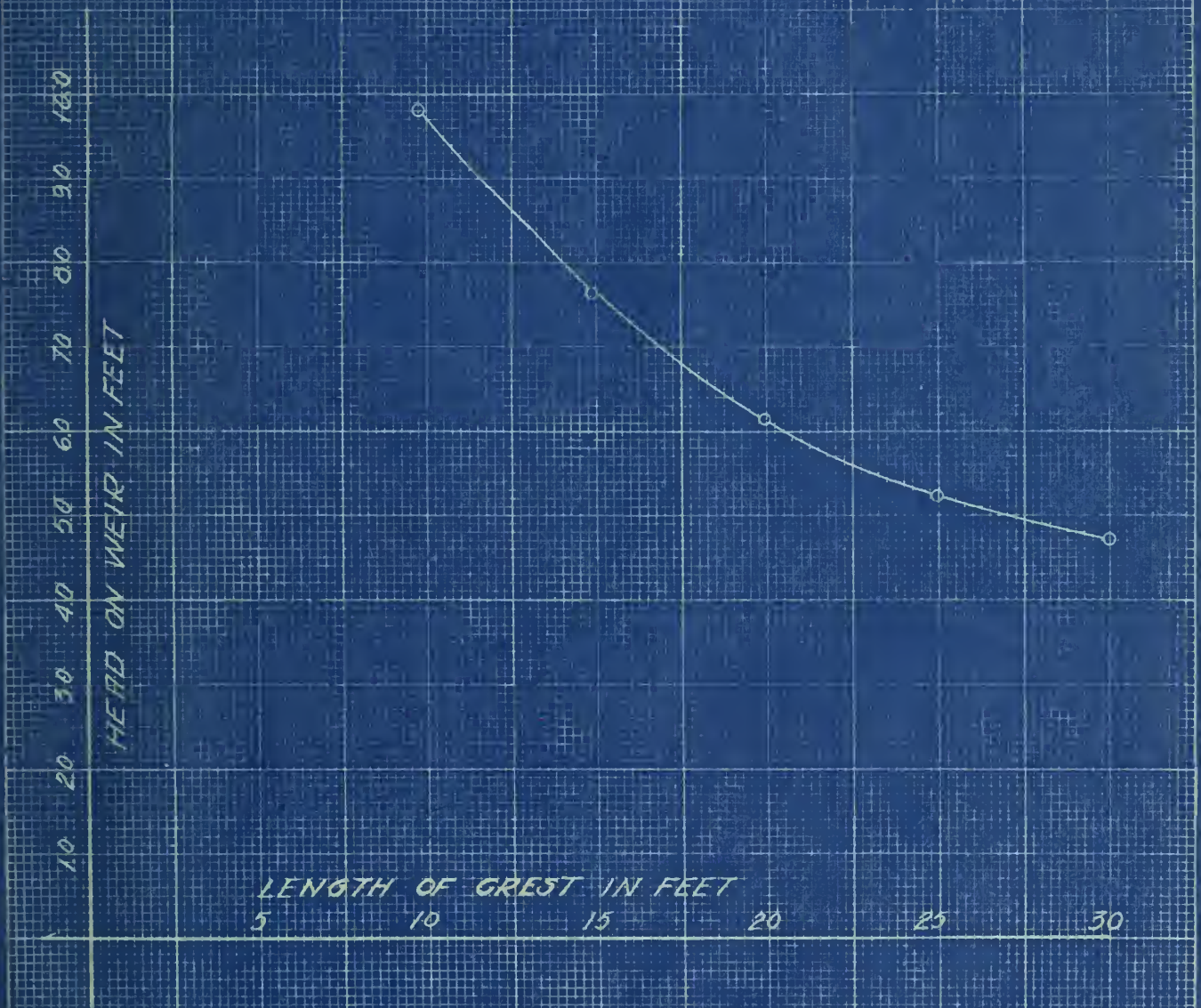


Computations.

The following computations of qauntities are the essential ones to have in mind in order to judge as to the feasability of the project.

Capacity of Reservoir.

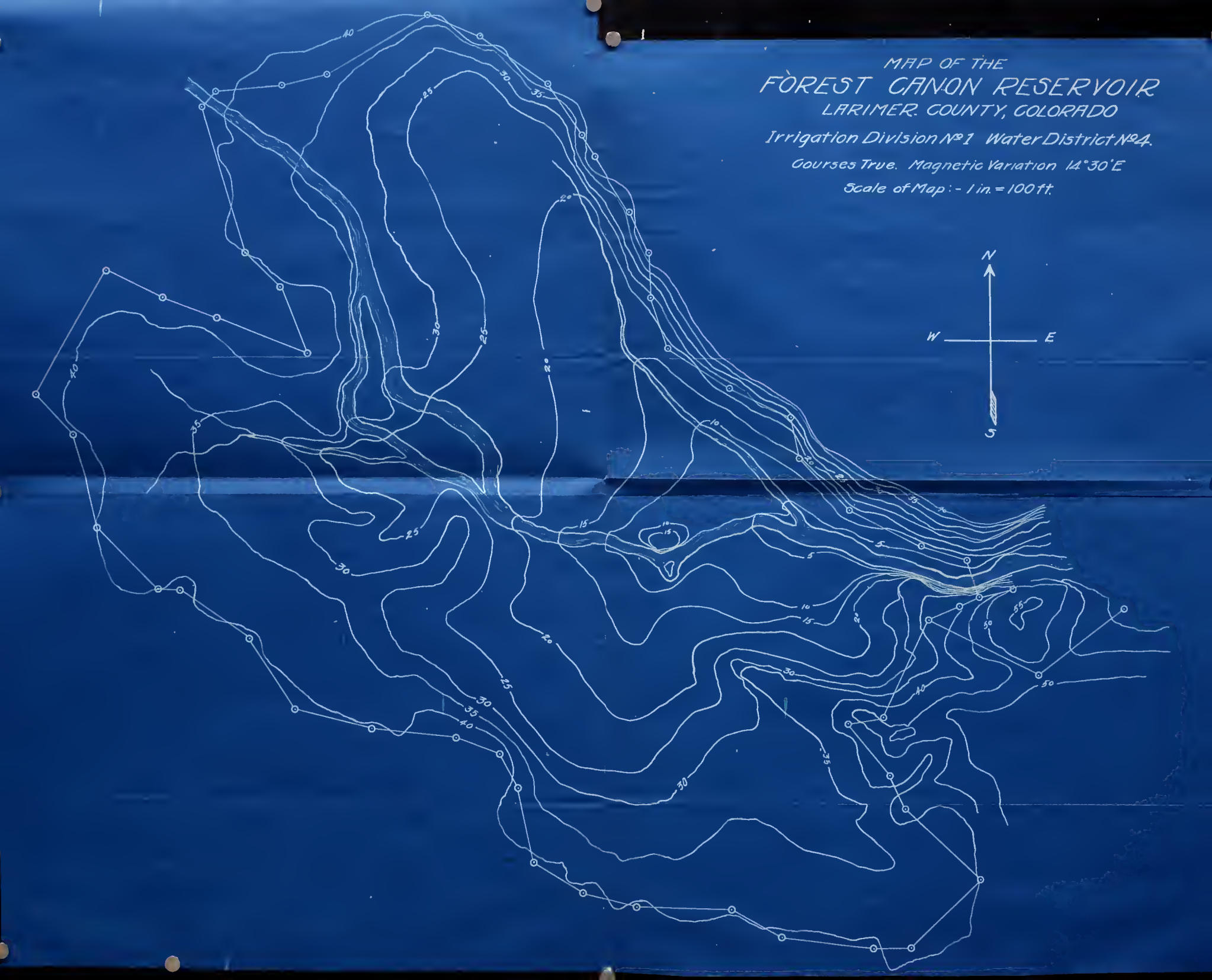
Cubic Contents of the Dam.

Excavation for Waste-weir.

In computing the capacity of the reservoir, the contour map of the reservoir site was used. The areas included between the contours was found by means of a polar planimeter and the contents of the reservoir computed by these end areas.

The cubic contents of the dam was found in much the same way. The center line of the dam was laid out and knowing the slopes of the sides the contours of the dam were laid out. The contents of the dam were than computed in the same manner as the capacity of the reservoir.

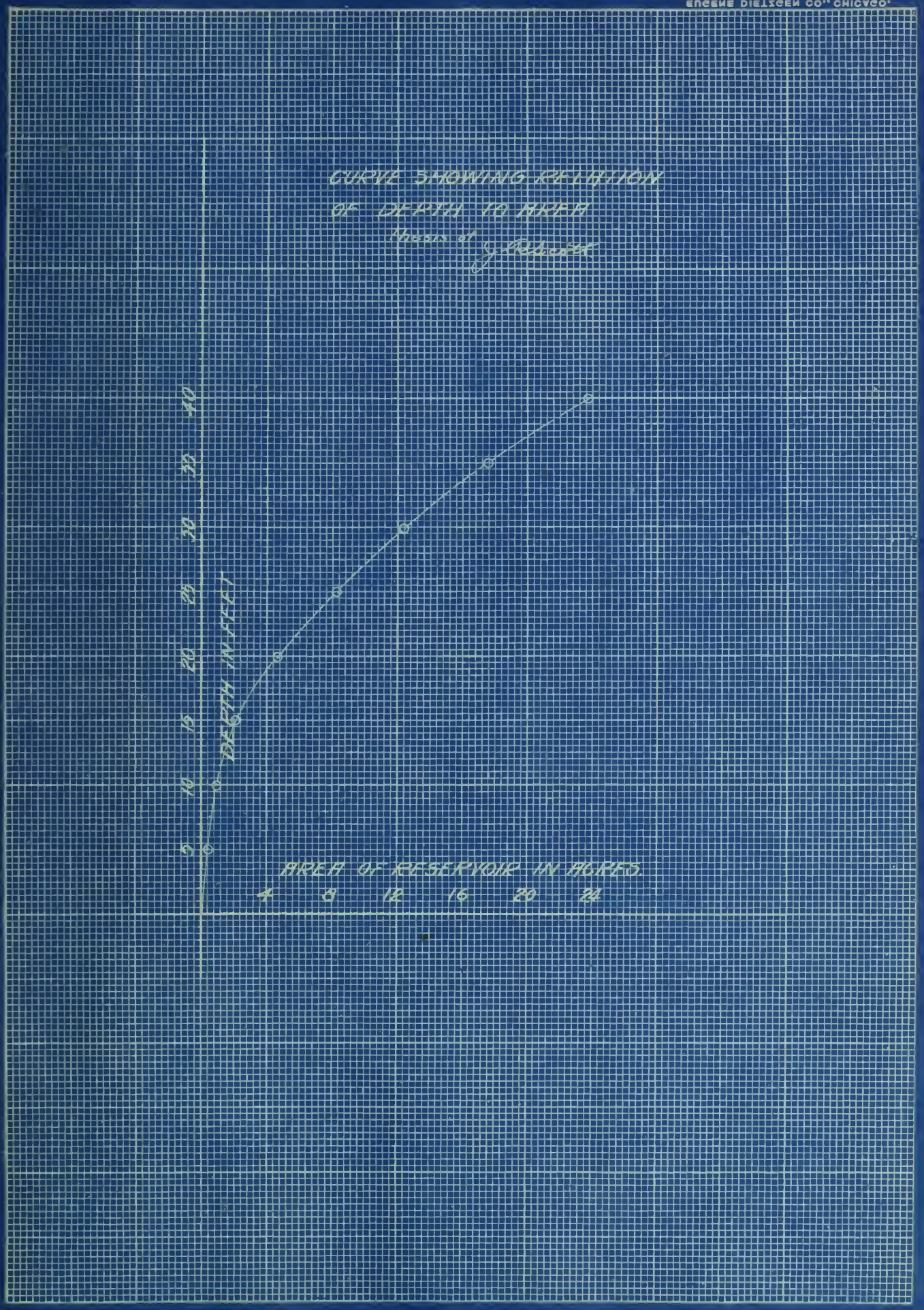
The excavation necessary for the construction of the waste-weir was taken from the contour map of the dam site. Knowing the elevation of the weir, the cut necessary at the points on the weir could be found.


MAP OF THE
FOREST CANON RESERVOIR
LARIMER COUNTY, COLORADO
Irrigation Division No 1 Water District No 4.
Courses True. Magnetic Variation 14°30'E
Scale of Map:- 1 in. = 100 ft.
N
W
E
S

Capacity of Forest Canon Reservoir.

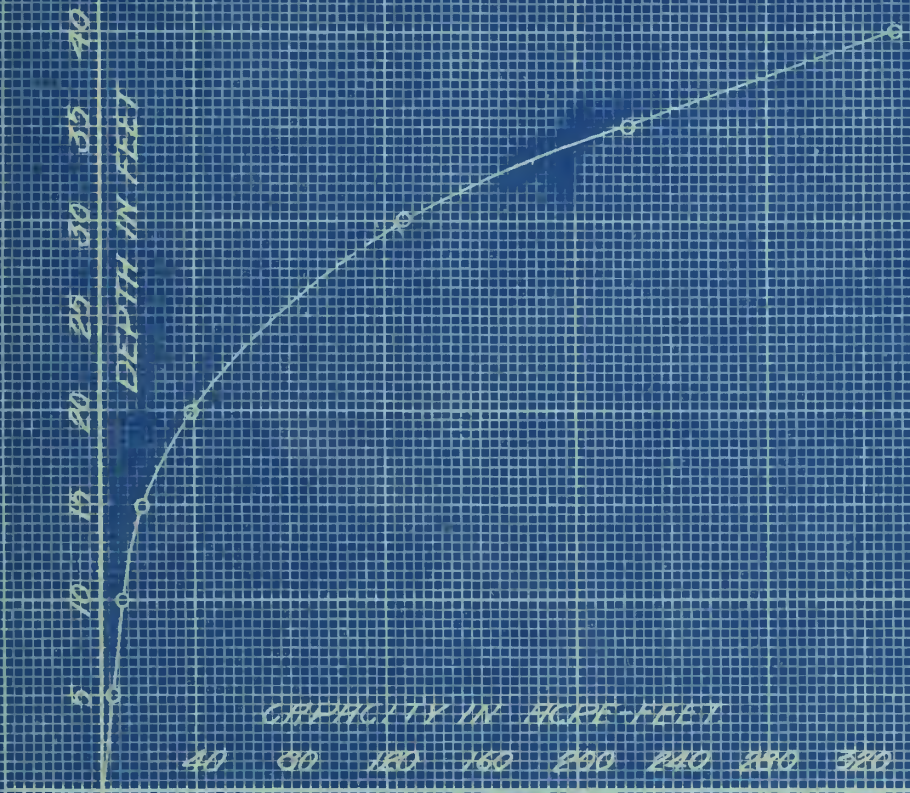
Contour.	Area in Acres.	Capacity in Acre-Feet.
0.0	0.0	0.0
5.0	0.34	2.50
10.0	1.64	5.04
15.0	2.77	19.60
20.0	5.55	36.00
25.0	10.90	84.00
30.0	12.80	118.00
35.0	17.12	220.00
40.0	24.26	307.00

On the following pages are found curves showing the relation of the heigh of the water level on the dam to the area of the water surface and to the capacity of the reservoir.



CURVE SHOWING RELATION OF DEPTH TO CAPACITY

Theirs of [illegible]



Design of Outlet Gates.

The object of this investigation is to provide a means of storing water during the wet season and discharging it into the stream again during the dry season. It is then only necessary to design the outlet gates for such a quanty of water as will be used during the irrigating period of the dry season.

Only two forms of outlet gates seem at all practicable for the above purpose. One plan is to place a sluice gate on the slope of the upstream side of the dam and operate it by means of an inclined shaft leading to a hand wheel located on the top of the dam. The other plan is to place a Ludlow gate valve in a valve chamber built in the center of the dam directly beneath the crest. This valve is then operated in a manner similar to the operation of the other. The first method is open to objection from the fact that the gate and the shaft are constantly in danger of being injured by the action of logs or ice in striking against them. The method of placing the valve in a valve chamber built in the inside of the dam is preferable to the other even though the expense of building the shaft is somewhat greater.

The total capacity of the reservoir is 13,000,000 cubic feet. Since the district to be irrigated consists of about four hundred acres, the amount of water which must be expected to flow through the gates can be estimated. A future increase in the height of the dam and the capacity of the reservoir should also be provided for without necessitating the

removal of the first gate.

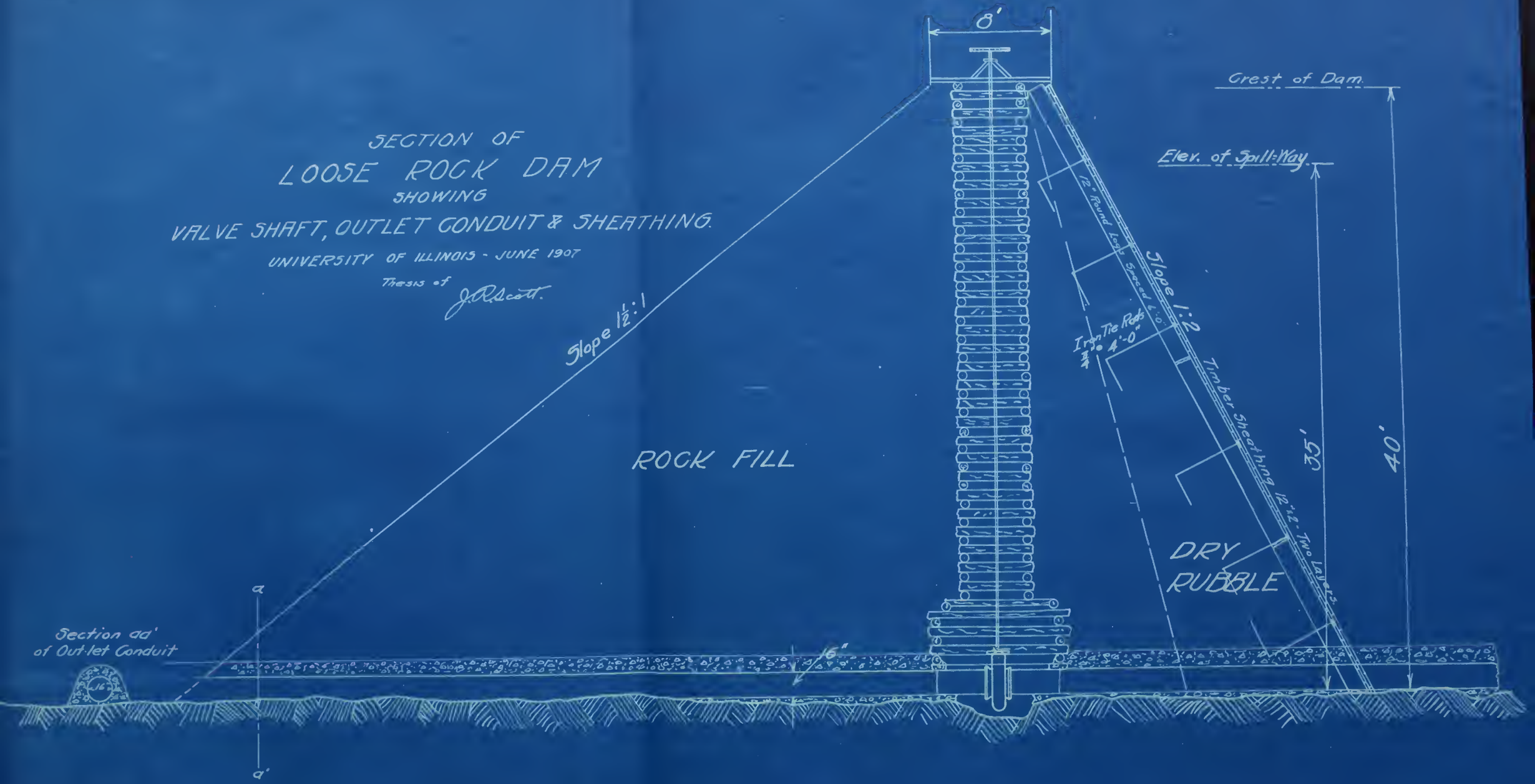
Having in mind the above conditions, a discharge of twenty five cubic feet per second was provided for. Assuming an average head of water of fifteen (15) feet on the outlet and assuming the coefficient of discharge to be six tenths (.6) it is found that one eighteen (18) inch conduit will give the required discharging capacity.

The shaft which operates the valve is placed directly over the valve and is built up of round logs laid to form a crib. This shaft is about four(4) feet square at the top and increases at the bottom to six(6) feet square. This enlargement at the bottom forms a valve-chamber in which the work of repairing the valve can be carried on if necessary. The rod which operates the gate of the valve is supported by means of wrought iron straps which are bolted to the side timbers of the shaft.

SECTION OF LOOSE ROCK DAM SHOWING VALVE SHAFT, OUTLET CONDUIT & SHEATHING.

UNIVERSITY OF ILLINOIS - JUNE 1907

Thesis of J. R. Scott.



Estimate of Cost.

The following estimate of the cost of the project, while rather rough and lacking in details, servos the purpose of this investigation in showing in a general way the items which enter into the cost of the construction and the method of estimating the same.

The principal source of imformation in regard to the cost of handleing materials and carrying on the work of construction was the report of the engineer in charge of the construction of a similar dam on the Stony Creek in California. This report was published under the direction of the United States Geological Survey and is probably very reliable. The conditions under which the work was carried on were very much the same and any differences have been provided for in the following estimate.

31 000 cu.yds. loose-rock in place	@$1.60	------	$ 4960.00
15 000 cu.yds. rock excavation	@$0.90	------	$ 1350.00
Concrete conduit, valves, rods, etc.		------	$ 500.00
Timber sheathing, crib work, etc.		------	$ 300.00
200 cu.yds. dry rubble wall,	@$3.00	------	$ 600.00
			$ 7710.00
20% for Engineering and contingincies		------	$ 1542.00
		Total -----	$ 9252.00

N

W E

S

WASTE WEIR

Map Showing
TOPOGRAPHY OF DAM SITE
FOREST CANON RESERVOIR
LARIMER COUNTY COLORADO.
University of Illinois June - 1907.
Thesis of. J. R. Scott.

Advertisement for Bids.

Rock-fill Dam and Spill-way.

Denver, Colorado, June 1, 1907.

Sealed proposals will be recieved until 12 o'clock noon on the thirtieth (30) of June, 1907, for the construction of a loose-rock dam and spill-way for the Forest Canon Reservoir Project in Larimer County, Colorado.

The work is to consist of approximately the following quantities of materials.

Loose Rock ----------31 000 cubic yards.

Rock Excavation ----------15 000 cubic yards.

Portland Cement ----------30 barrels.

Plans and general drawings of the proposed work may be had together with the specifications, instructions to bidders and forms of proposal, at the office of ----------Engineer in charge, Denver, Colorado.

Bids must be submitted according to the instructions attached to the specifications and must be accompanied by a certified check for 500 dollars, which check will be returned to the unsuccessful bidder immediately after the award of the contract.

The right to reject any or all bids is especially reserved.

Engineer in Charge.

Instructions to Bidders.

(1).- No bids will be recieved for any part of the work herein described from parties who cannot show a reasonable acquaintance with,and preparation for the proper performance of the class of work for which the bid is submitted. Evidence of such competency must be furnished if desired.

(2).- Proposals must be made on the blank forms to be obtained at the office of the engineer in charge.

(3).-The contract shall be let as a whole.but the following items are to be considered as the parts going to make up the entire estimate and prices must be given for each.

(a).- Rock-fill----------per cubic yard.

(b).- Rock excavation-------per cubic yard.

(c).-Portland cement--------per barrel.

All machinary,including rock drills,derricks and overhead travellers must be furnished by the contractor and shall be considered as part of his equipment.

(4).- Each proposal must be accompanied by a written guarantee in the sum of 500 dollars,signed by two responsible persons to the effect that if the proposal is accepted within thirty days of the opening of the proposal,the bidder will within ten days of being notified of such acceptance,enter into a contract ond give bond with good and sufficient securities,and in case of failure of bidder to enter into contract and give bond.they willpay the difference between the amount of the bid and the amount for which the contract may be made with another party.

(5).- The amount of the penalty of the bond to be furnished by the contractor will not be le s than one tenth of nor more than the full sum of the consideration of the contract.

Form of Proposal.

To the Reservoir and Irrigation Co,Denver,Colorado.

Gentlemen,:-

The under signed propose to do all of the work and furnish all of the material in accordance with the printed form of contract and specifications,a copy of which is herewith annexed,and bind themselves ,on the acceptance of the proposal,to enter into and execute a contract in the form of said enclosed specifications and contract for the execution of the following work at the prices as below.:-

Rock-fill---------- ---------per cubic yard(--------)

Rock excavation---------- ------per cubic yard(--------)

Portland cement----------per barrel(----------)

Enclosed is a certified check for 500 dollars,which sum is forfeited to the Reservoir and Irrigation Co if the parties making this proposal fail to enter into the contract with approved securities,within ten days of the time the contract is awarded to said parties.

Respectfully,

Form of Contract.

" Time of Commencement, Rate of Progress and Time of Completion."

The party of the second part agrees that he will commence the work herein contracted for within ten days after notice of award of the contract; that the rate of progress of the work shall be such as ,in the opinion of the engineer in charge,is necessary for completion within the time herein specified and that he will so conduct the said work that on or before the first day of September.1907,the whole work covered by this contract and specifications shall be entirely completed.

"Monthly Estimates."

In order to enable the said contractor to prosecute the work advantageously,the engineer shall,once a month,make an an estimate in writing of the amount of work done,and materials delivered to be used on the work and the value thereof according to the terms of the contract. The first such estimate shall be of the amount or quantity of the work done and materials delivered since the party of the second part commenced the performance of the contract on his part. And every subsequent estimate (except the final one) shall be of the amount or quantity and value of the work done since the preceding estimate was made. And such estimates of amount and quantity shall not be required to be made by strict measurement or with exactness,but they may at the option of the engineer be approximately only.

Upon each such estimate being made, the parties of the first part will pay the party of the second part the following percentages thereof, to wit:

80% thereof up to and until such a time as the total work and materials shall amount to 1000 dollars.

90% thereof after the total estimate of such work and materials delivered shall have amounted to 1000dollars, until the party of the first part shall have fully and completely performed this contract on his part.

"Repair Fund."

The party of the second part hereby further agrees to make all of the needed repairs on the dam and waste-way for a period of nine months after the completion of the work: and he hereby agrees that the party of the first part is authorized to retain out of the money payable to him, under his agreement the sum of five percent on the amount of the contract and to expend the same, or so much thereof as may be required, in making the aforesaid ropairs ; and he hereby further agrees to be responsible for any accident that may occur on account of the defective condition of the work.

" Final Estimate."

When, in the opinion of the engineer in charge, the work shall be completely finished on the part of the contractor, the engineer shall proceed with all reasonable care to measure up the work and shall make up a final written estimate of the same. The engineer shall then imform the party of the first part as to the amount due the contractor, and this amount shall be paid within the limit of ten days after the making up of the final estimate.

"Engineer's Estimates."

The estimates of the engineer in charge shall be final and conclusive and shall be unchangeable except by some further written agreement between the parties to this contract.

"Damages for Delays."

And the party of the second part hereby further agrees that the said party of the first part is hereby authorized to deduct and retain out of the money which may be due or become due the party of the second part, under this agreement as damages for the noncompletion of the work within the specified.

The extent of the above mentioned damages to be determined by the engineer in charge.

"Discharge of Unpaid Claims of Workmen."

Said contractor further agrees to assume all of the risk of properly financeing the work and shall pay promptly the workmen employed on the work so that no claims may be placed on the finished work for back pay.

"Unforseen Difficulties."

The contractor further agrees to assume all of the risk of successfully carrying on the work of construction and shall have no claims against the party of the first part on account of losses due to unforseen difficulties.

"Protection of Finished Work."

The contractor further agrees to be responsible for any and all damages to materials or finished work to the full amount of the payments thereon before the final acceptance of the work.

" Protection of Property and Lives."

The said contractor also agrees to indemnify and save harmless the party of the first part from all claims for damages for any injuries or damages to person or property occasioned by the execution of the work called for in this contract.

" The abandonment of Contract."

Said contractor further agrees that if the work as called for under this contract is abandoned or is not being executed in good faith ,or that the progress of the work is unsatisfactory,the party of the first part shall have the right to notify the contractor to discontinue the work and shall have the right to proceed with the work as he may see fit.

In case of the cancellation of the contract under the above conditions the amount to be paid the contractor for work done according to the requirements of the contract,shall be determined by the engineer in charge.

"Cleaning up after Completion."

When the work is completed all loose material and other debris shall be removed from the vicinity of the dam. This cleaning up shall be carried on under the direction of the engineer in charge and shall not be considered satisfactory except with his approval.

"Caring for flow of stream during Construction."

The contractor further agrees to provide satisfactory means of caring for the flow of the stream during the progress of the work and such means must meet the approval of the engineer in charge.

" Contractor to keep Foreman onground."

At all times when the work is in progress,there shall be a foreman or head workman on the ground,and also copies of the plans and specifications. Instructions given to such foreman or head workman shall be considered as having been given to the contractor himself.

"Faults to be corrected before finalAcceptance."

Failure on the part of the engineer to condemn faulty work shall not be construed as the acceptance of the same and the party of the first part shall have the right to have the work replaced before final acceptance is made.

" No guarantee as to Correctness of Surveys."

The contractor shall be required to carry on all of his own engineering work in the feild and the plans furnished herewith are not gauranteed to be correct. It is essential that the reservoir site should be visited by persons who contemplate entering into the contract as the nature of the work is such that it willexpediate the carrying on of the work.

"Interpretation of the Contract."

The engineer in charge shall be the referee in all disputes in regard to the interpretation of the specifications. He shall have the authority to decide as to the meaning in the following instances,-

(a).-Where the meaning is obscure and uncertain.

(b).-In cases of discrepencies between plans and specifications.

(c).-As to what is implied beyond that which is specifically described.

(d).-In case changes of plans or methods of work are afterwards decided upon.

"Settlement of Disputes."

To prevent all disputes and litigation,it is further and between the parties of this contract,that the engineer in charge shall be the referee,in all cases,to determine the amount,quality,accepttability,and fitness of the several kinds of work which are to be paid for under this contract,and to decide upon all questions which may arise as to the fulfillment of said contract on the part of said contractor,and his decision and determination,shall be final and conclusive.

"Extra Work."

All extra work shall be paid for at the same rate as the contract calls for and the amount of such work is to be determined by the engineer in charge.

"Definitions."

'Party of the first part' is the Reservoir and Irrigation Co of Denver,Colorado.

'Party of the second part' is the contractor to whom the contract is let.

'Engineer in charge' is ----------,of Denver,Colorado.

"Documents composing the Contract."

It is understood by the contracting parties that the following documents are essential parts of t e complete contract: The advertisement,the instructions to bidders,the proposal, alldrawingsmaps,and plans ,hereto attached or herein described the specifications,and specific contract.

" Meaning Understood"

Said contractor hereby admits that he has read each and every clause in this contract, and fully understands the meaning of the same, and hereby agrees to comply with all of the terms, covenants and agreements herein set forth.

(Signed) ----------

(Signed) ----------

Specifications.

The dam is to be of the loose-rock type and is to form a solid structure upon which the timber sheathing is to be placed. The waste-way is to be located at a point about fifty feet south of the dam and is to be formed by excavating the rock to the required dimensions. The following specifications shall govern the work of construction and choice of materials.

(1).- The dam shall be constructed of loose rock.

(2).- The height of the dam shall be forty feet above the level of the water of the stream at the dam site.

(3).-The slope of the upstream side shall be one half to one.

(4).- The slope of the down stream side shall be one and one half to one.

(5).- The width of the crest shall be eight feet.

(6).- The material which forms the body of the dam may be large boulders or fragments of the rock blasted from the waste-weir.

(7).- The material may be placed by dropping it from any form of overhead cableway but not in such a manner as to injure the valve shaft or the timber sheathing.

(8).- The upstream side shall consist of a dry rubble wall laid eight feet thick at the bottom and six feet thick at the top.

(9).-The vertical timbers shall placed in the wall spaced six feet apart and the tie rods which hold the in place shall be placed as shown on the dwawings.

(10).- The timbers which are to make up the vertical frame work shall not be less than twelve inches in diameter.

(11).- The tie rods shall be 3/4"in diameter and four feet long,six inches of the length being bent at right angles as is shown in the drawings.

(12).- The sheathing shall consist of two layers of 2"x12" planking placed horizontally and spiked to the vertical posts. The joints shall be broken and a coat of liquid asphalt, applied hot, shall be placed between the two layers.

(13).- Asphalt shall be used in sufficient quantities to seal the joints of the sheathing with the side walls of the canon and the outlet conduit.

(14).- The valve-shaft shall consist ot a timber crib-work measuring 4' x 4' at the top of the shaft and forming a valve box 6'x6' around the valve. All loose-rock which comes in contact with this shaft shall be placed by hand.

(15).- The outlet-conduit shall be built of concrete of a 1:2:5 mixture. The section shall be circular and have a diameter of 16". The conduit shall extend thirty feet beyond the toe of the upstream slope and ten feet beyond the toe of the downstream slope.

(16).- The valve shall be a 16" ludlow gate-valve.

(17).- The valve-rod shall consist of a rod 1" in diameter extending from the valve to the hand wheel on the crest of the dam.

(17).- The spill-way shall be at an elevation of thirty five feet above the level of the water in the stream at the dam site.and shall have a cross-section of 20'x5'. The spillway shall be located as shown on the plans.

Conclusion.

The following gives a summary of the projected work and and goes to show that the project is entirely feasable.

Total cost of Project.	$ 9250.00
Time necessary for completion	3 months.
Capacity of Reservoir.	225 acre-feet.
Cost per acre-foot stored	$ 4.25
Area to be furnished with water	200 acres.

The per acre-foot stored is somewhat higher than in other parts of Colorado,but as the land to be irrigated is to be benefited in a much greater porportion than in other districts, the cost is not prohibitive.

As compared with other projects it may be seen at once that this project is a very small one. However in this particular part of the state no one large project could be developed owing to the nature of the topography of the country and any large project or system must necessarily be made up of a number of such small ones.